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(54) **DISPLAY DEVICE INCLUDING A LIGHT GUIDE PLATE WITH PROTRUSIONS**

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G02F 1/13 (2006.01)

G02F 1/1335 (2006.01)

(52) **U.S. Cl.**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,705,283 B2 7/2020 Liu et al.

11,150,399 B2 10/2021 Liao et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 108983447 A * 12/2018 G02B 6/0035

CN 113156570 A 7/2021

(Continued)

OTHER PUBLICATIONS

European Patent Office, Extended European Search Report, EP Patent Application No. 21215874.5, Jun. 29, 2022, ten pages.

(Continued)

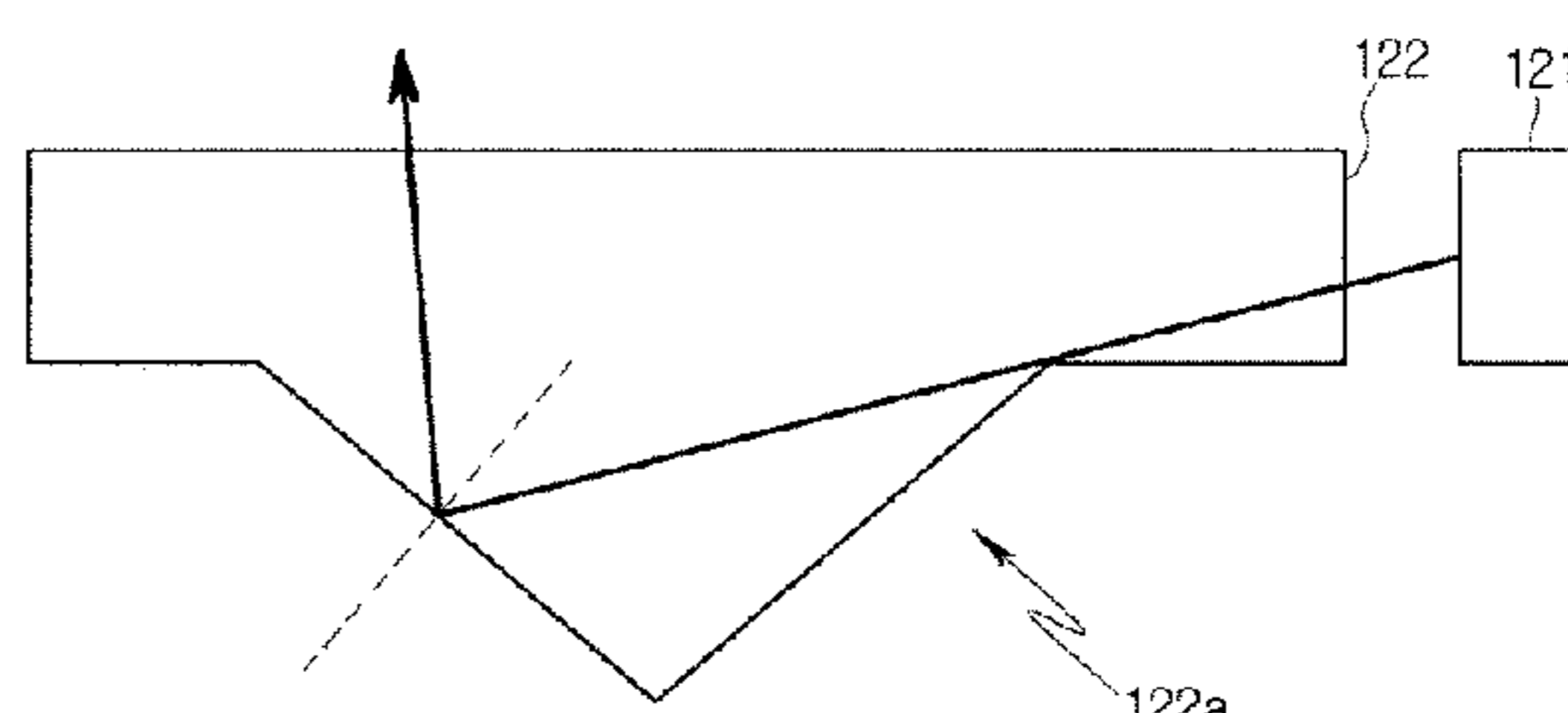
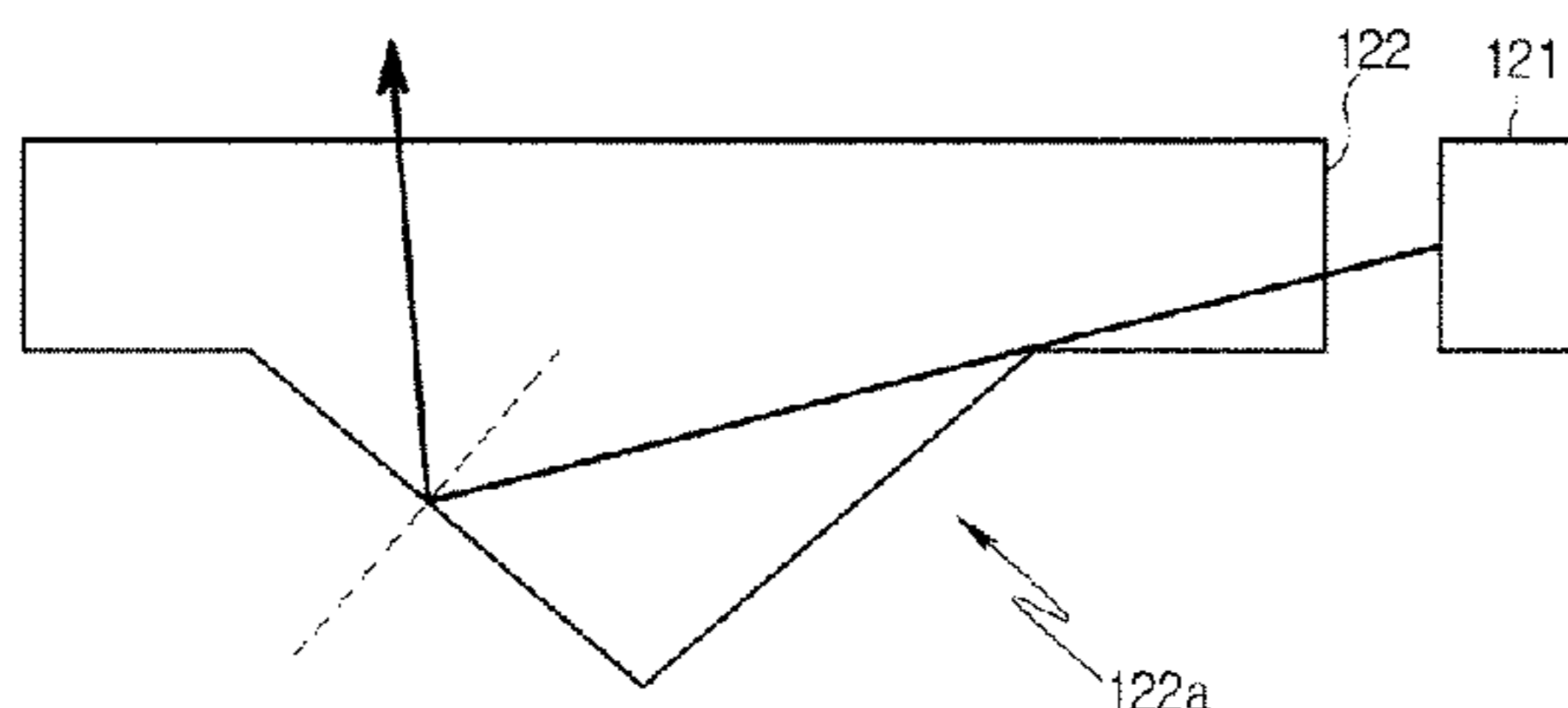
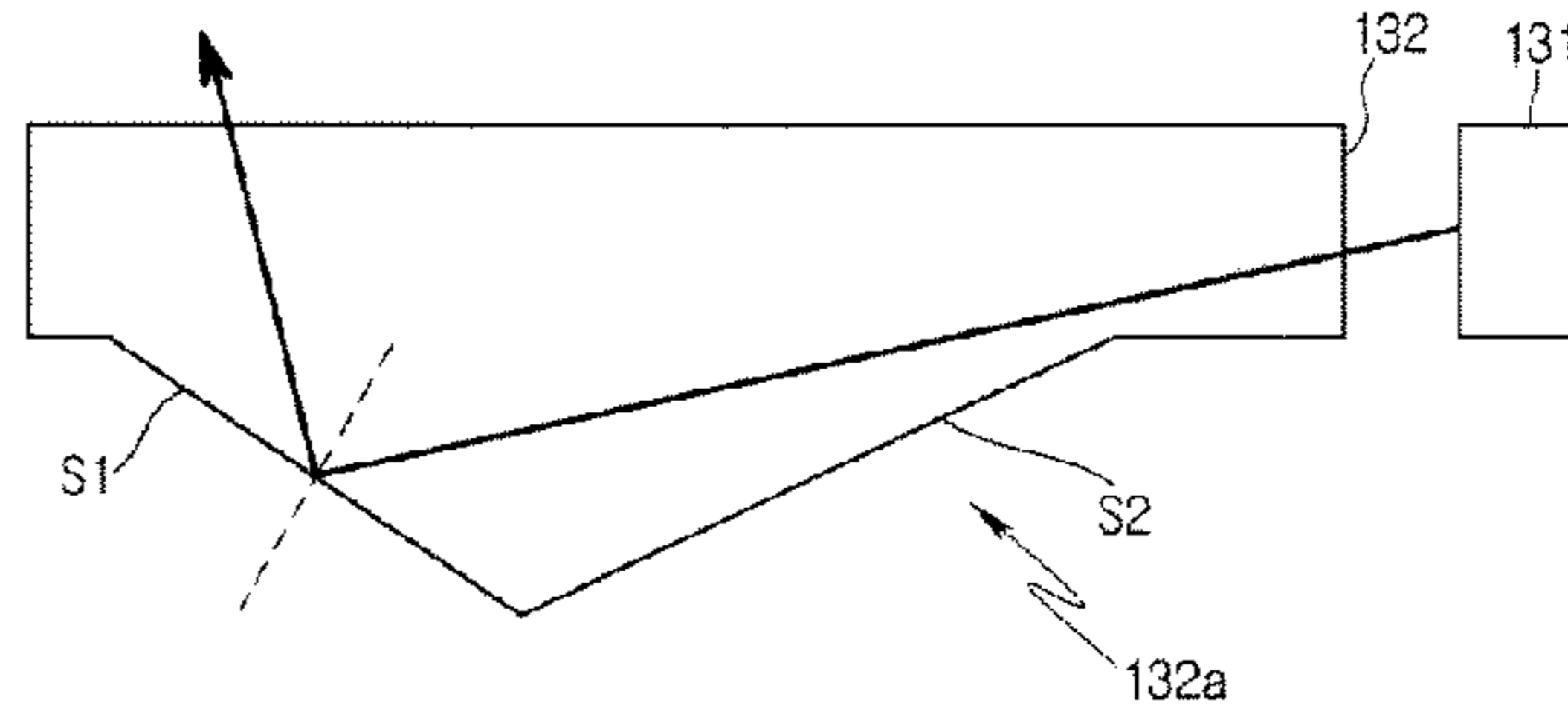
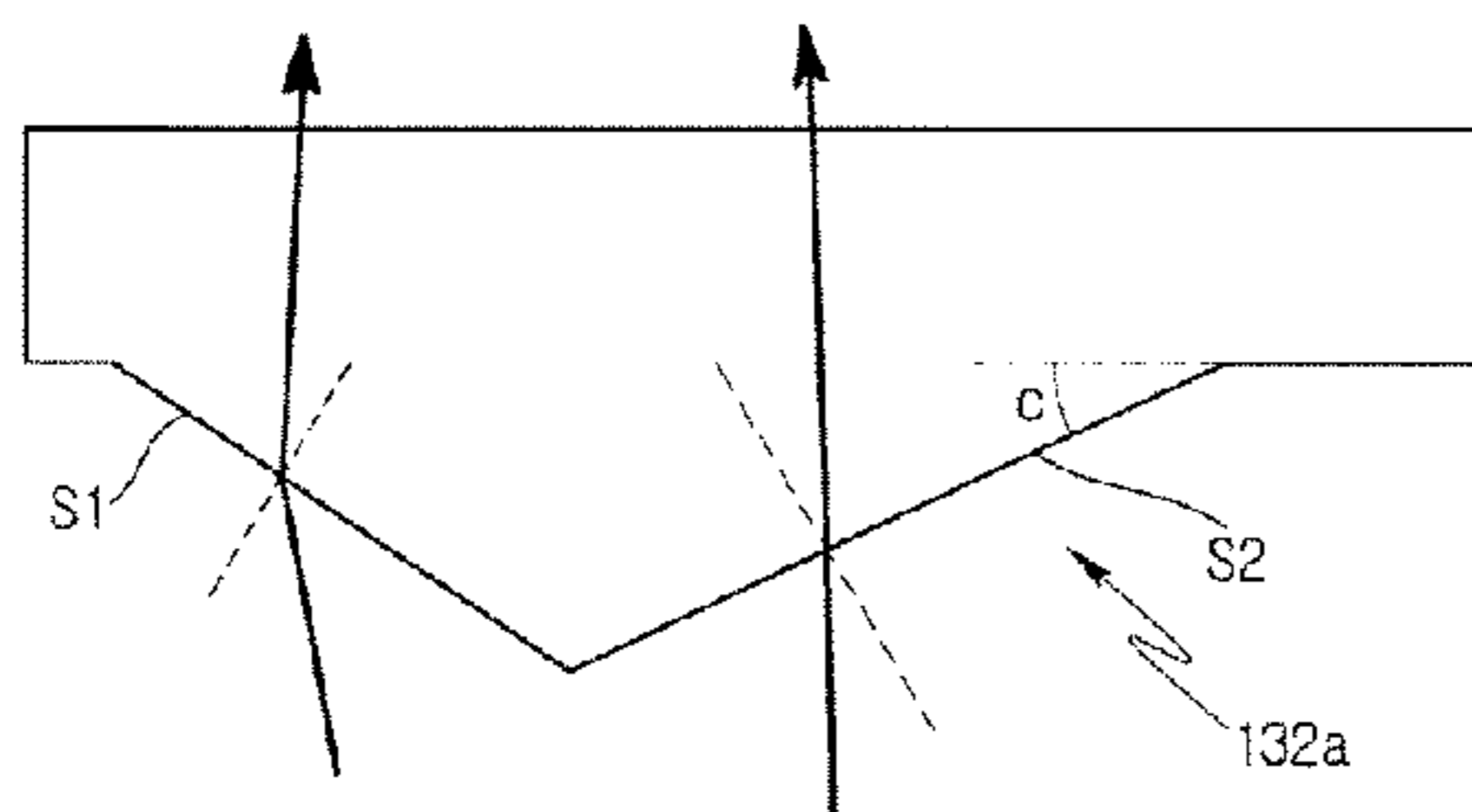
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(57) **ABSTRACT**

A display device includes a display panel configured to display an image, a first backlight unit that is disposed under the display panel and outputs first light, and a second backlight unit that is positioned between the display panel and the first backlight unit and outputs second light, wherein the first backlight unit includes a first light guide plate having first patterns protruding or recessed from a rear surface of the first light guide plate, the second backlight unit includes a second light guide plate having second patterns protruding from a rear surface of the second light guide plate, and the second patterns have an asymmetric pyramid shape.

15 Claims, 9 Drawing Sheets



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(2013.01); *G02F 1/133627* (2021.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0109686 A1 5/2006 Sugiura
2014/0043377 A1 2/2014 Tanaka et al.
2014/0098563 A1* 4/2014 Kim G02B 6/0076
362/613
2017/0069236 A1 3/2017 Klippstein et al.
2020/0003946 A1* 1/2020 Klippstein G02B 6/0073
2020/0005718 A1 1/2020 Fattal
2020/0064535 A1 2/2020 Haan et al.
2020/0183073 A1 6/2020 Osumi et al.
2021/0191027 A1 6/2021 Liao et al.
2021/0390914 A1 12/2021 Fattal

FOREIGN PATENT DOCUMENTS

KR 10-2015-0062758 A 6/2015
KR 10-2019-0116435 A 10/2019
TW M595237 U 5/2020
WO WO 2006/109921 A1 10/2006
WO WO 2010/055907 A1 5/2010
WO WO 2017/065745 A1 4/2017

OTHER PUBLICATIONS

Taiwan Intellectual Property Office, Office Action, TW Patent
Application No. 110149324, Dec. 20, 2022, 11 pages.
United States Office Action, U.S. Appl. No. 15/556,239, filed Oct.
20, 2022, 18 pages.

* cited by examiner

FIG. 1

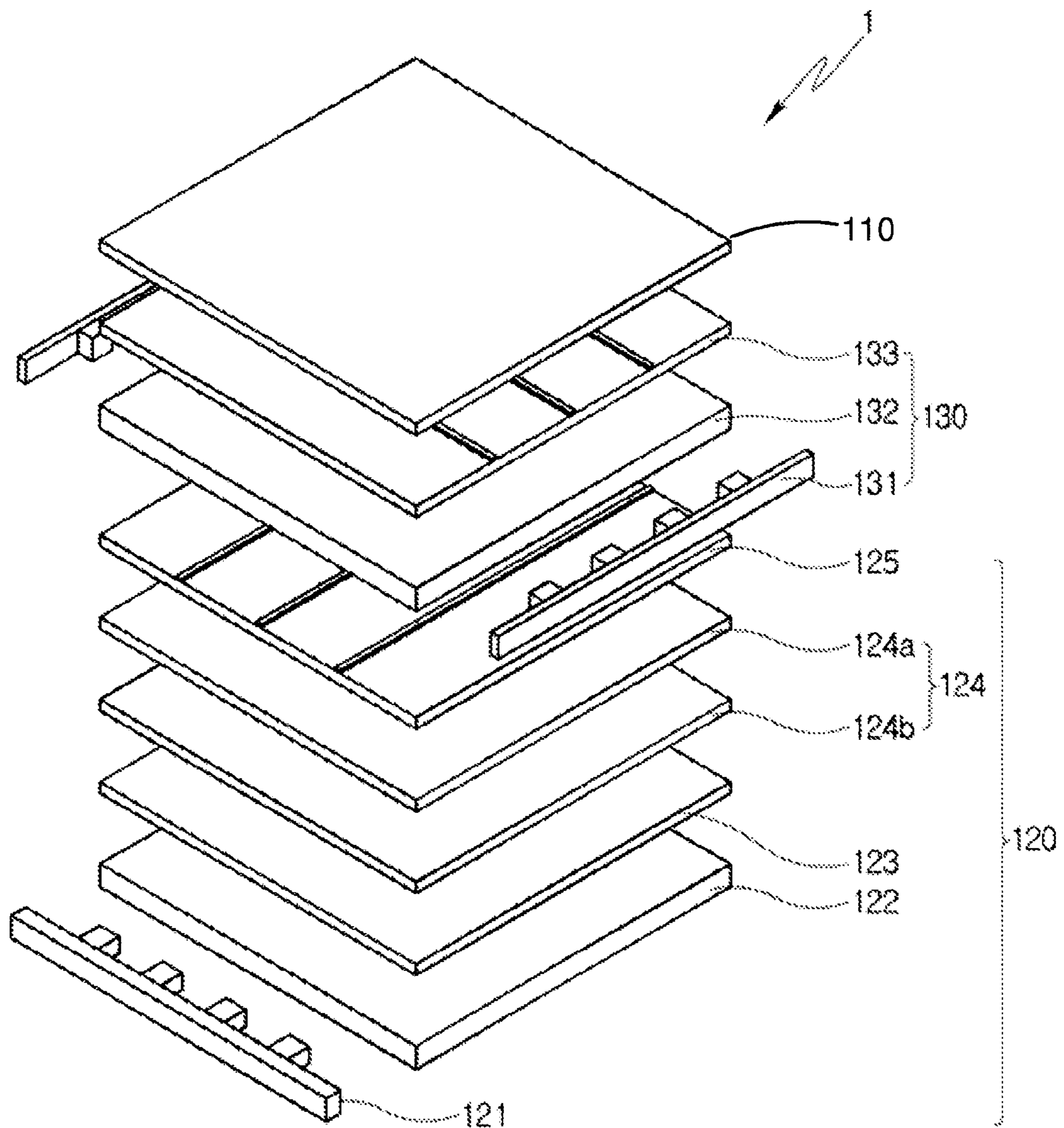


FIG. 2

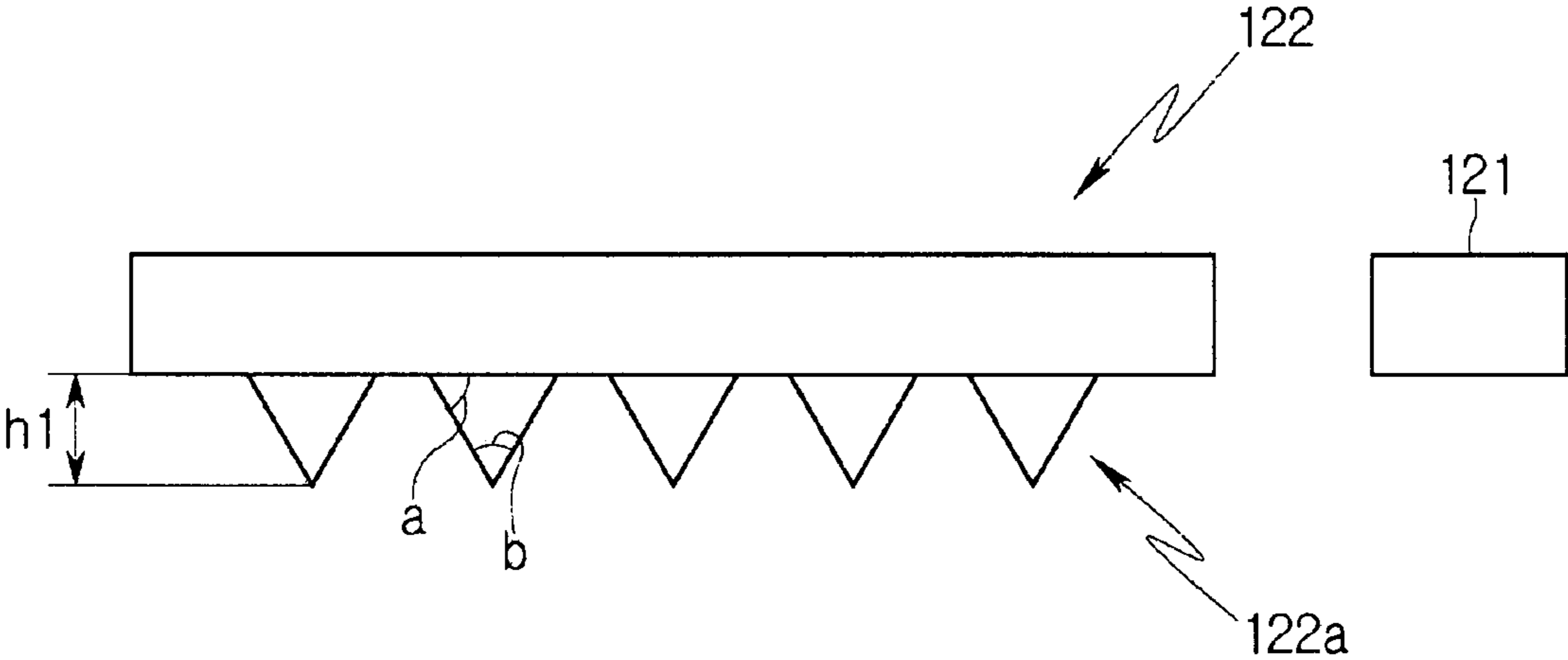


FIG. 3

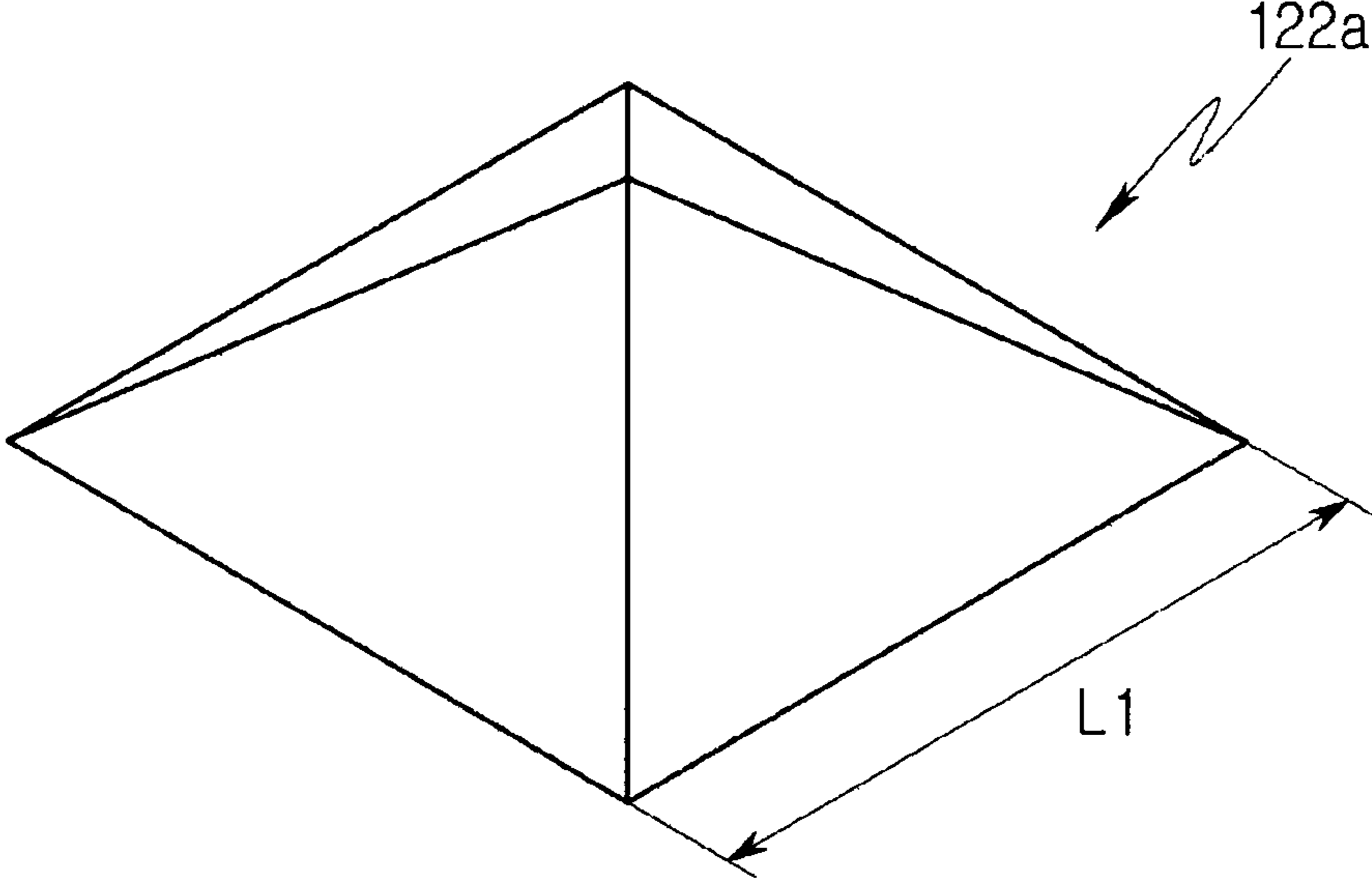


FIG. 4

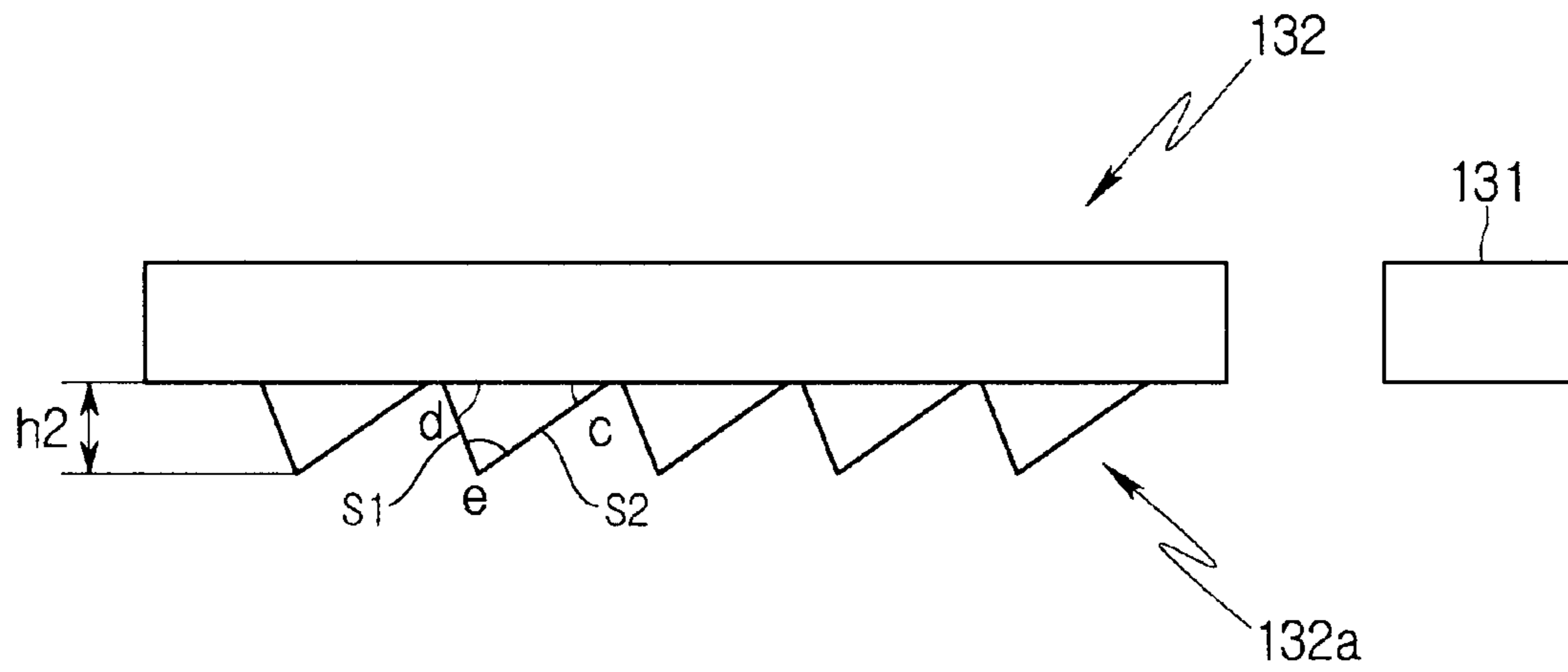


FIG. 5

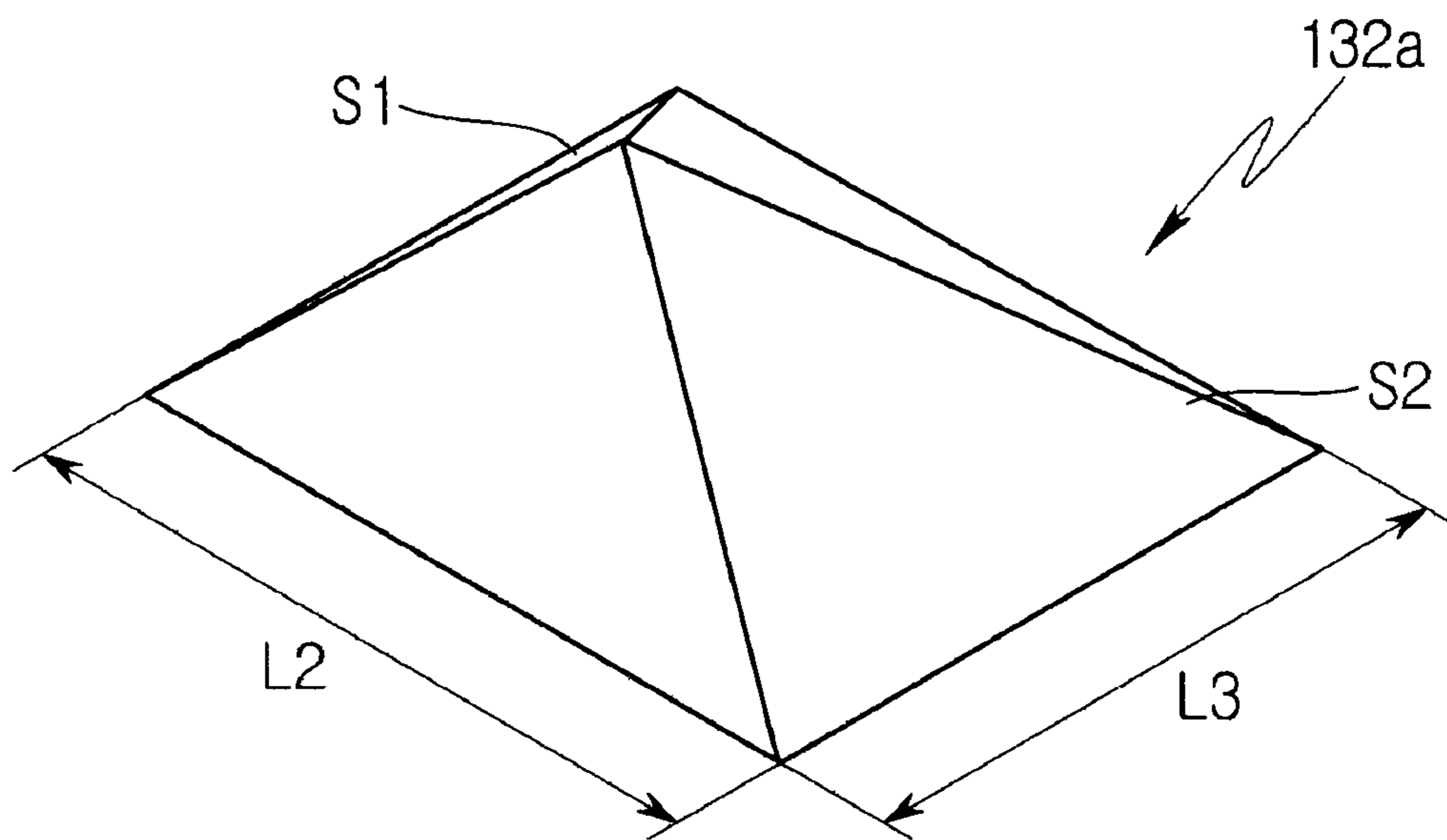


FIG. 6

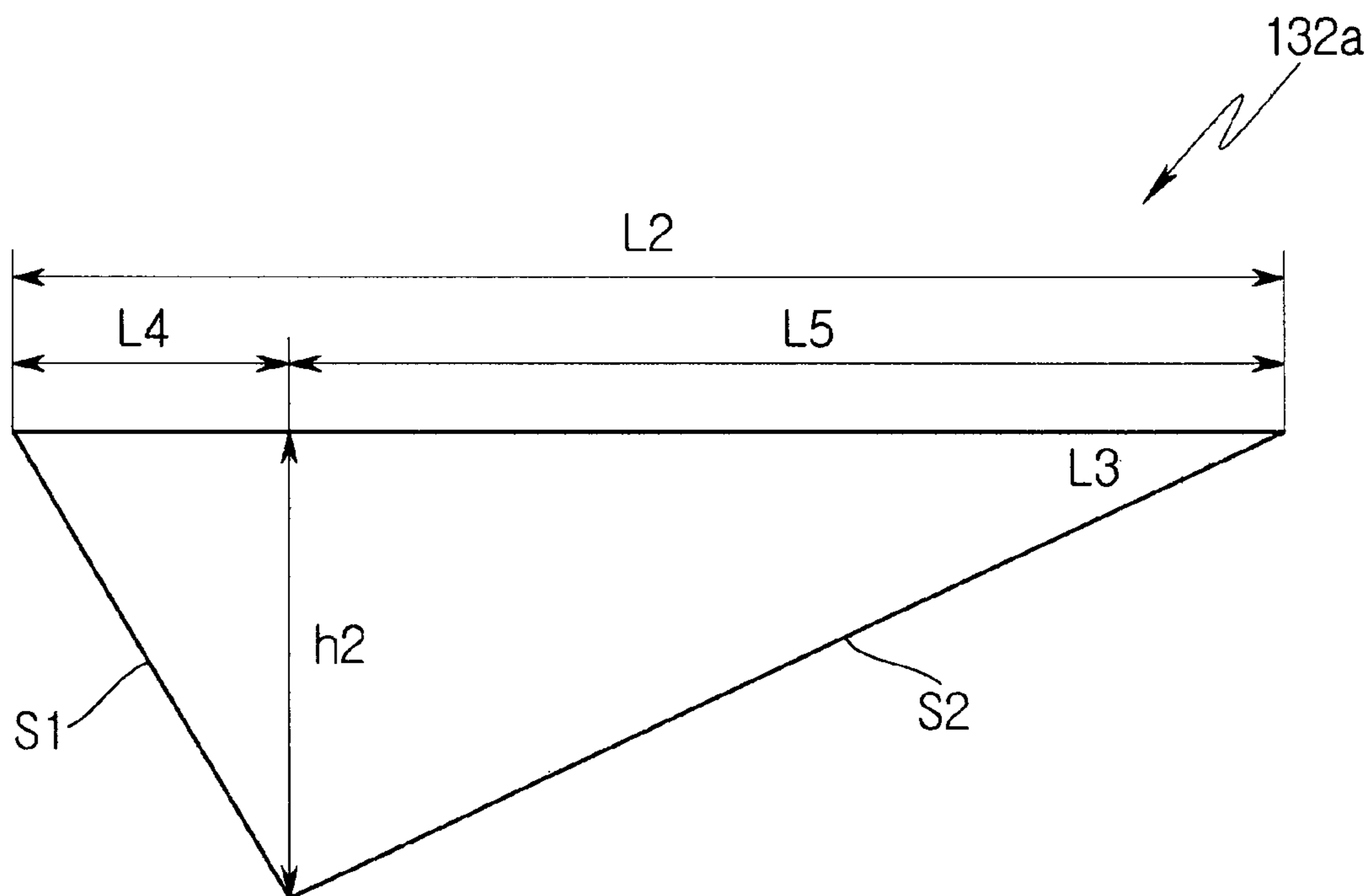


FIG. 7

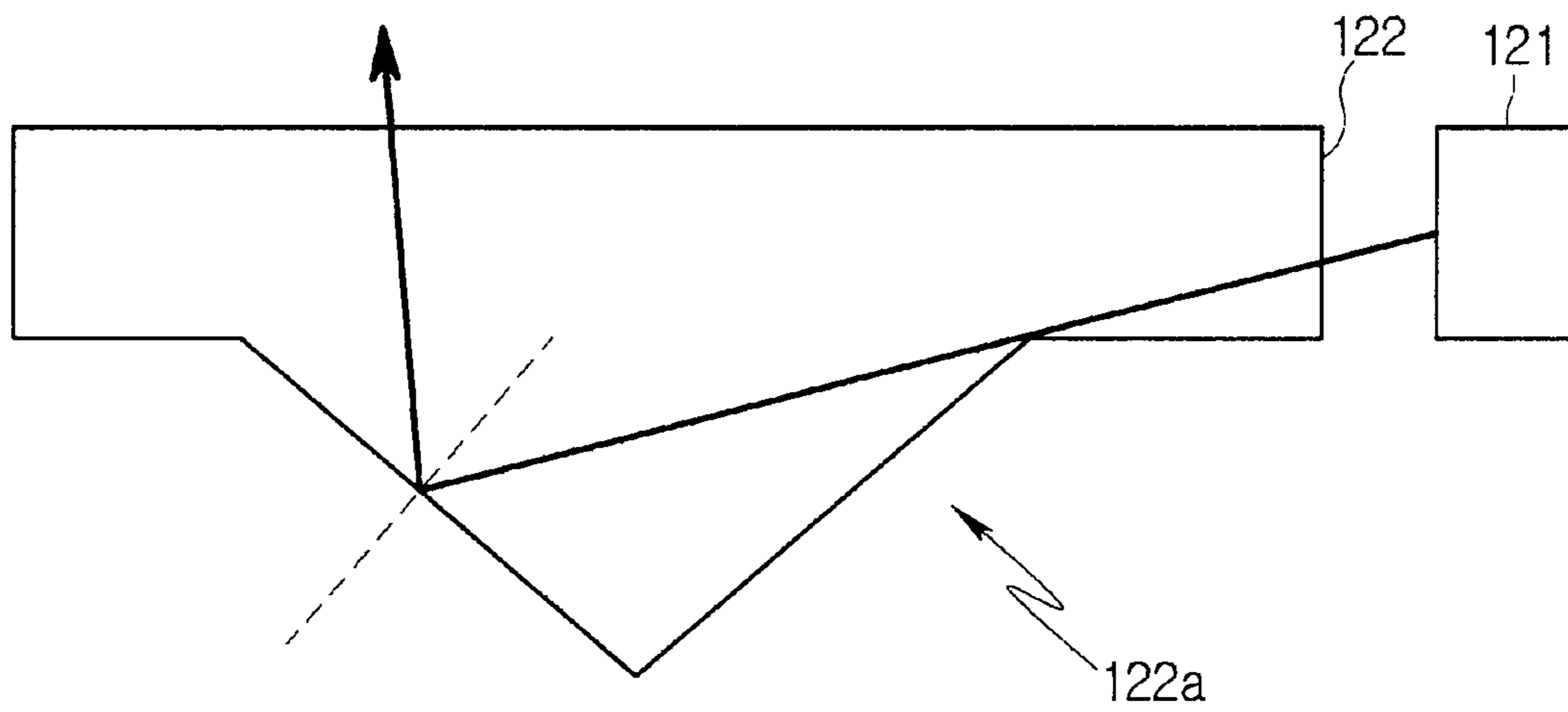
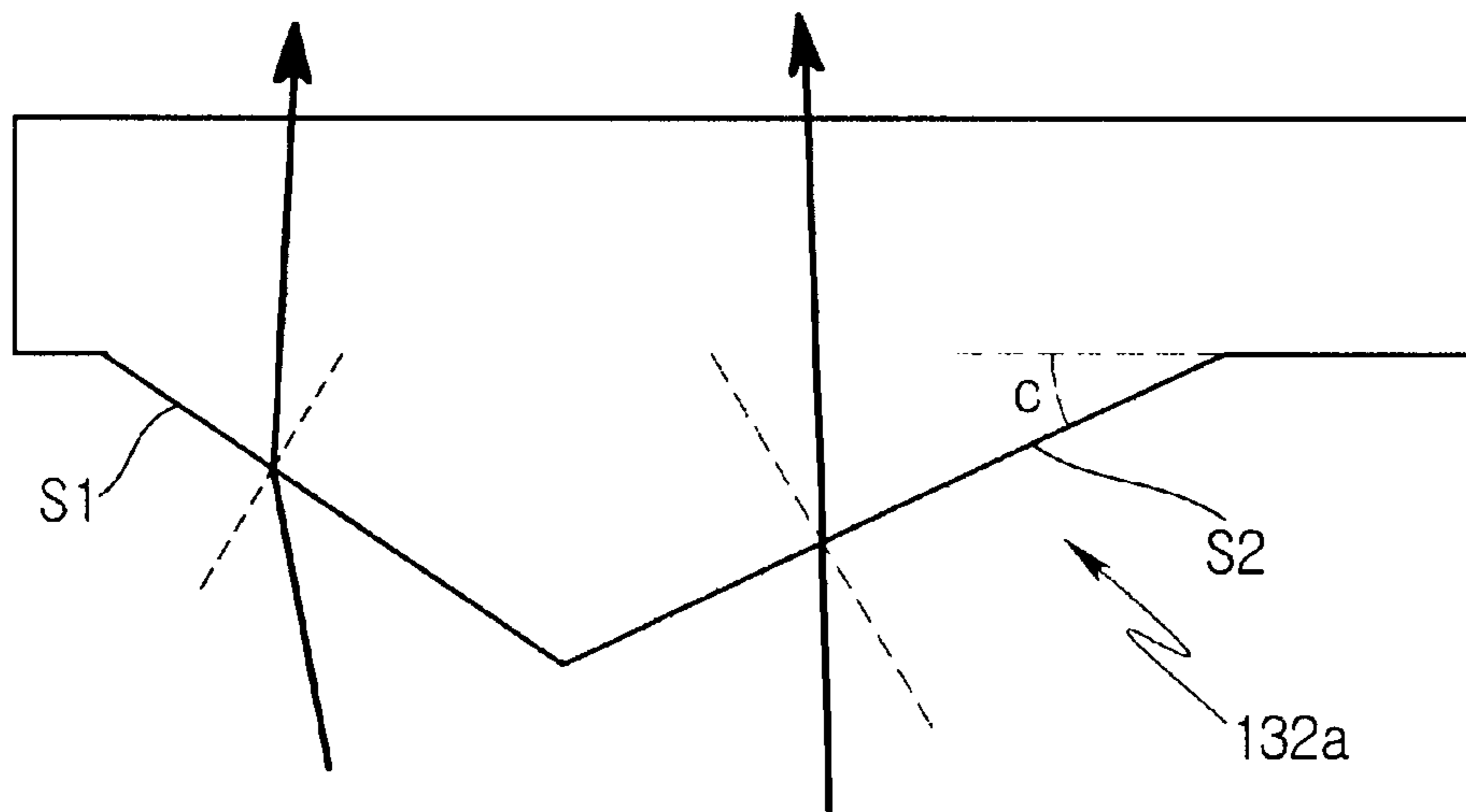


FIG. 8

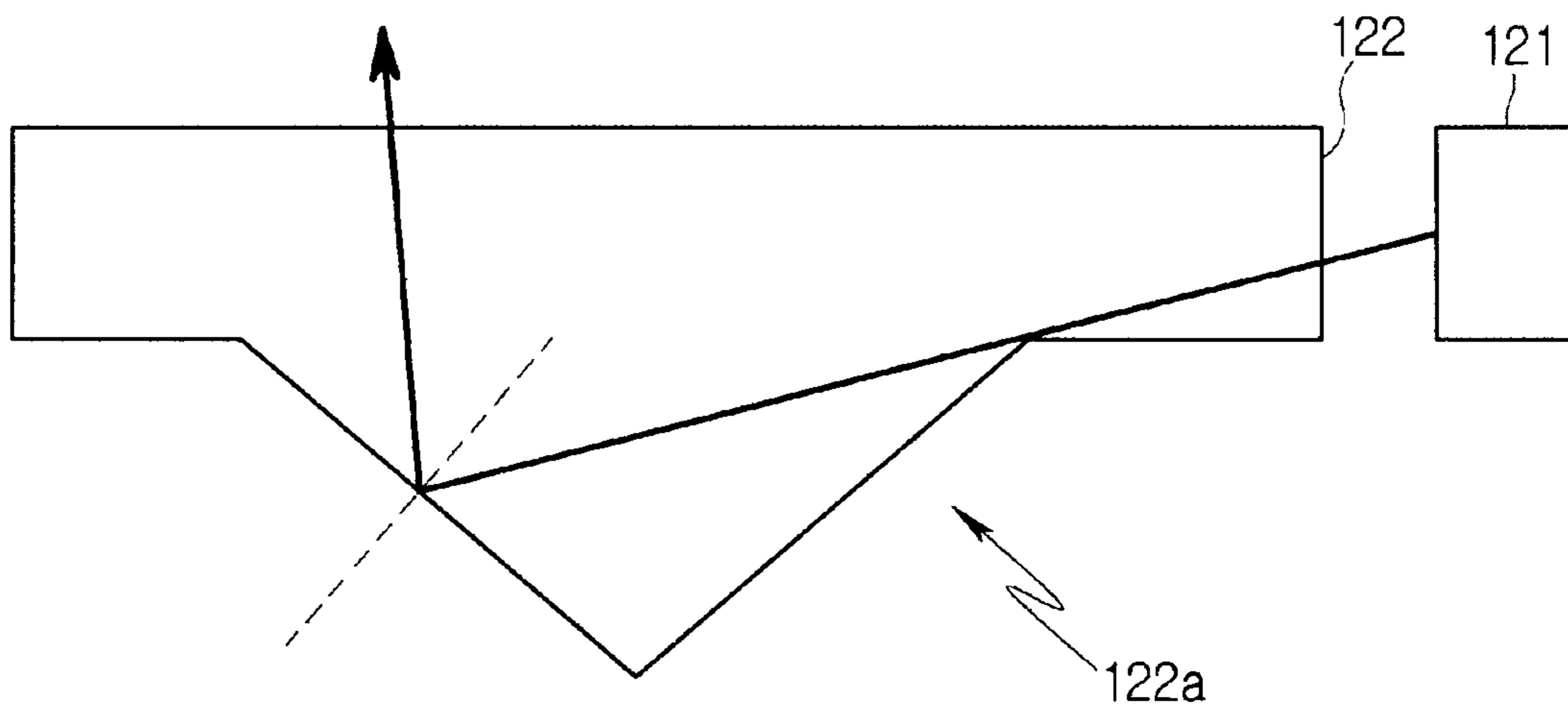
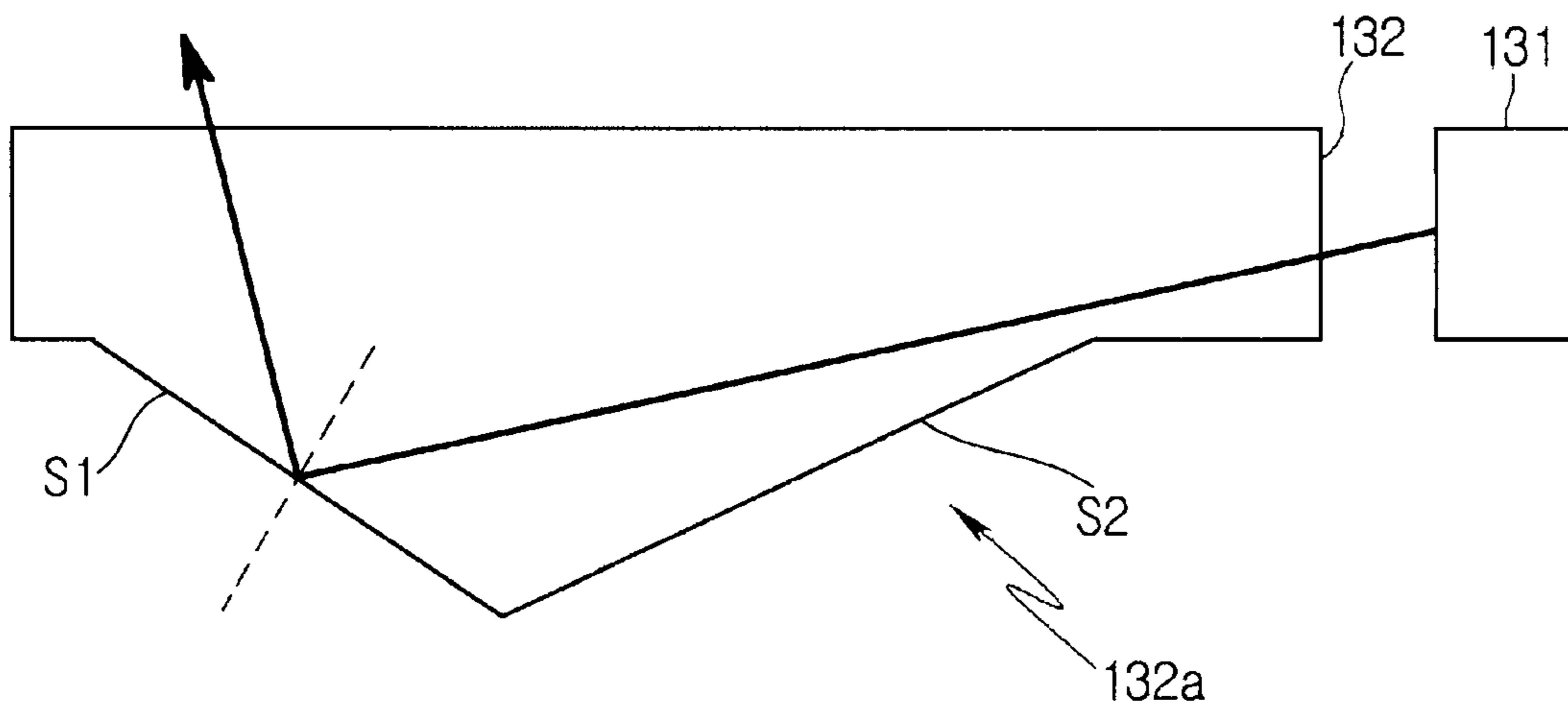


FIG. 9

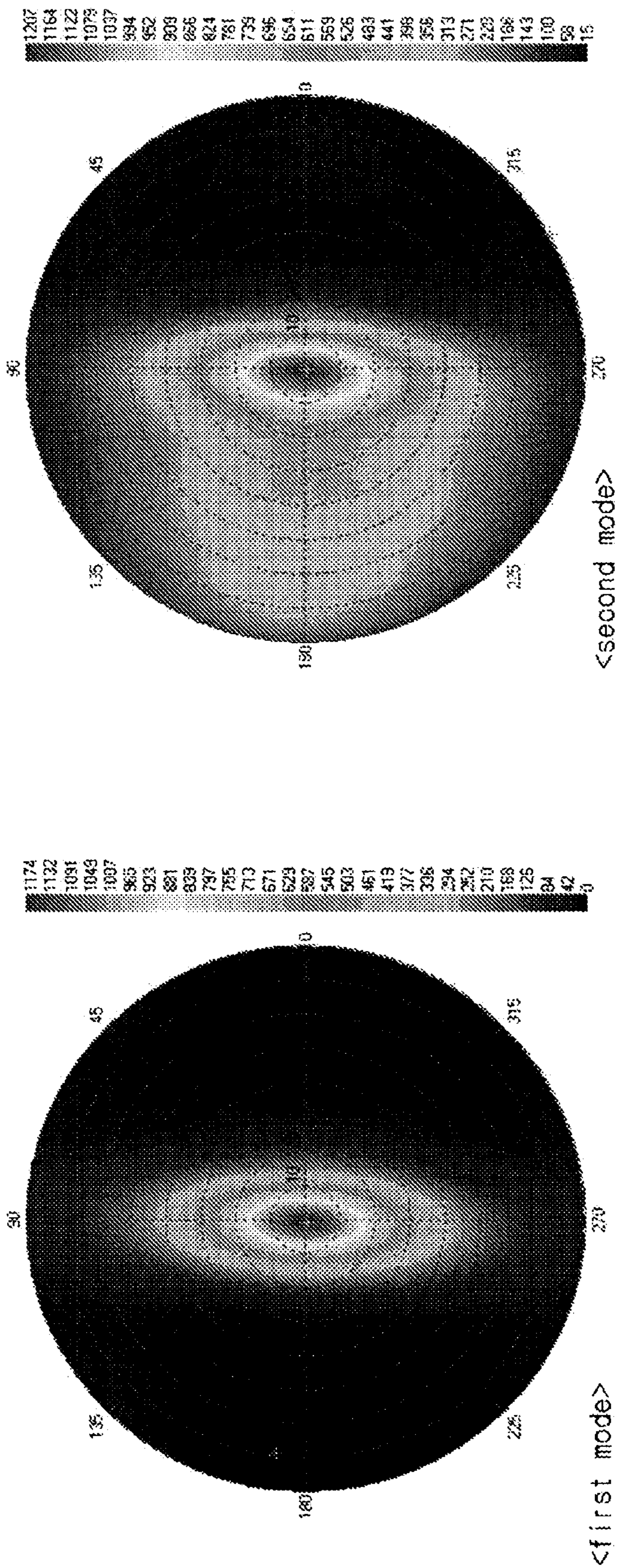


FIG. 10

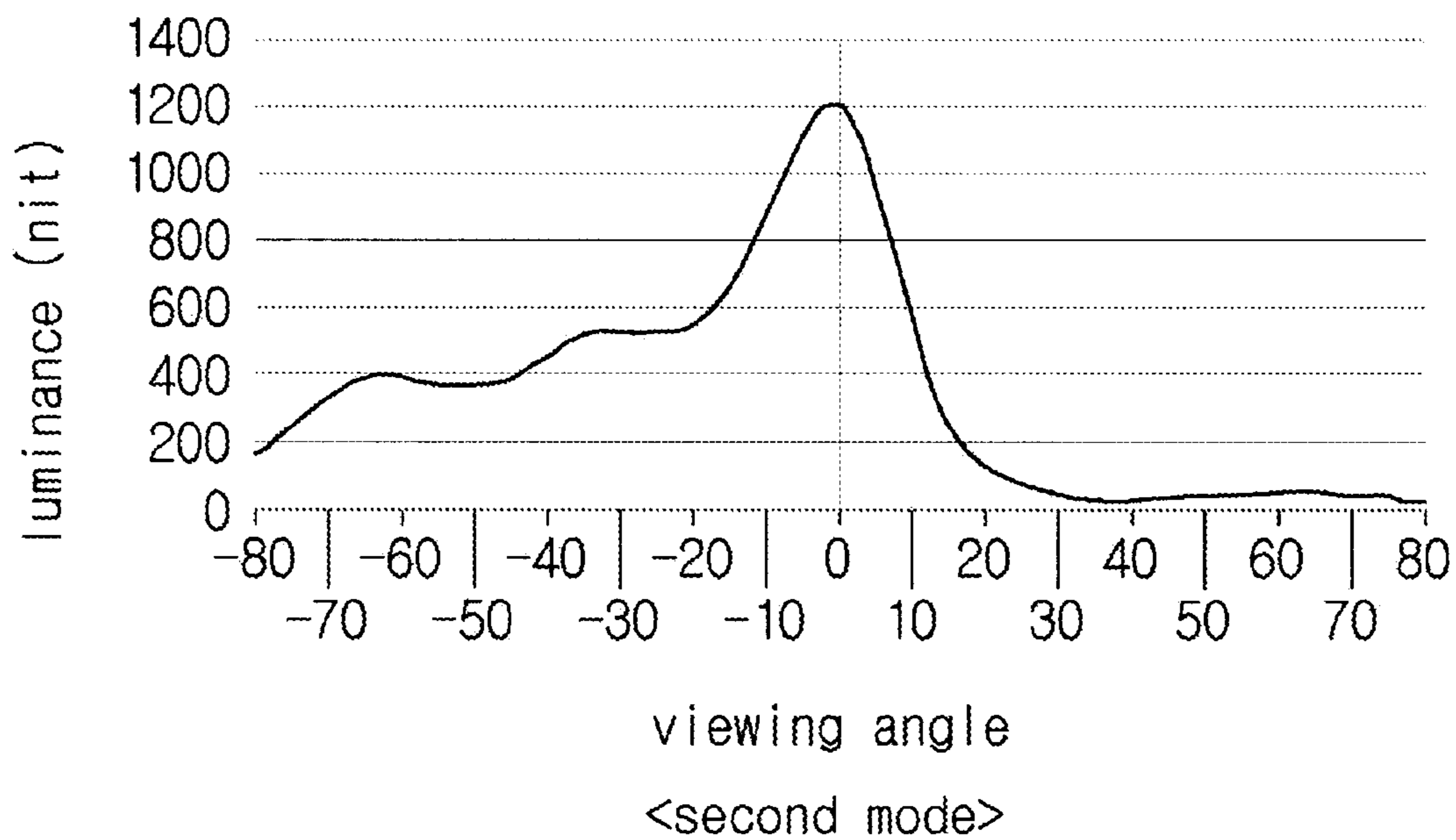
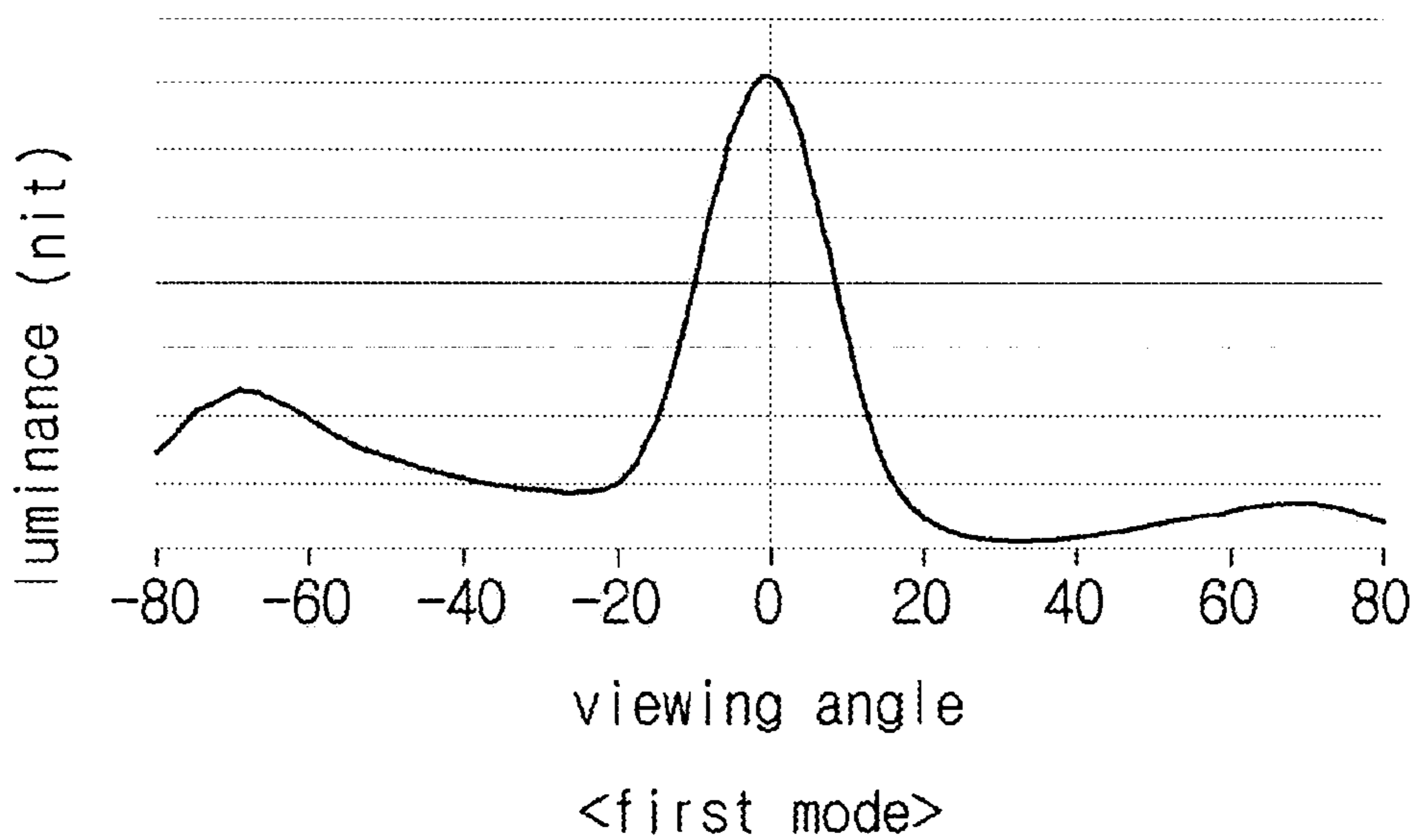
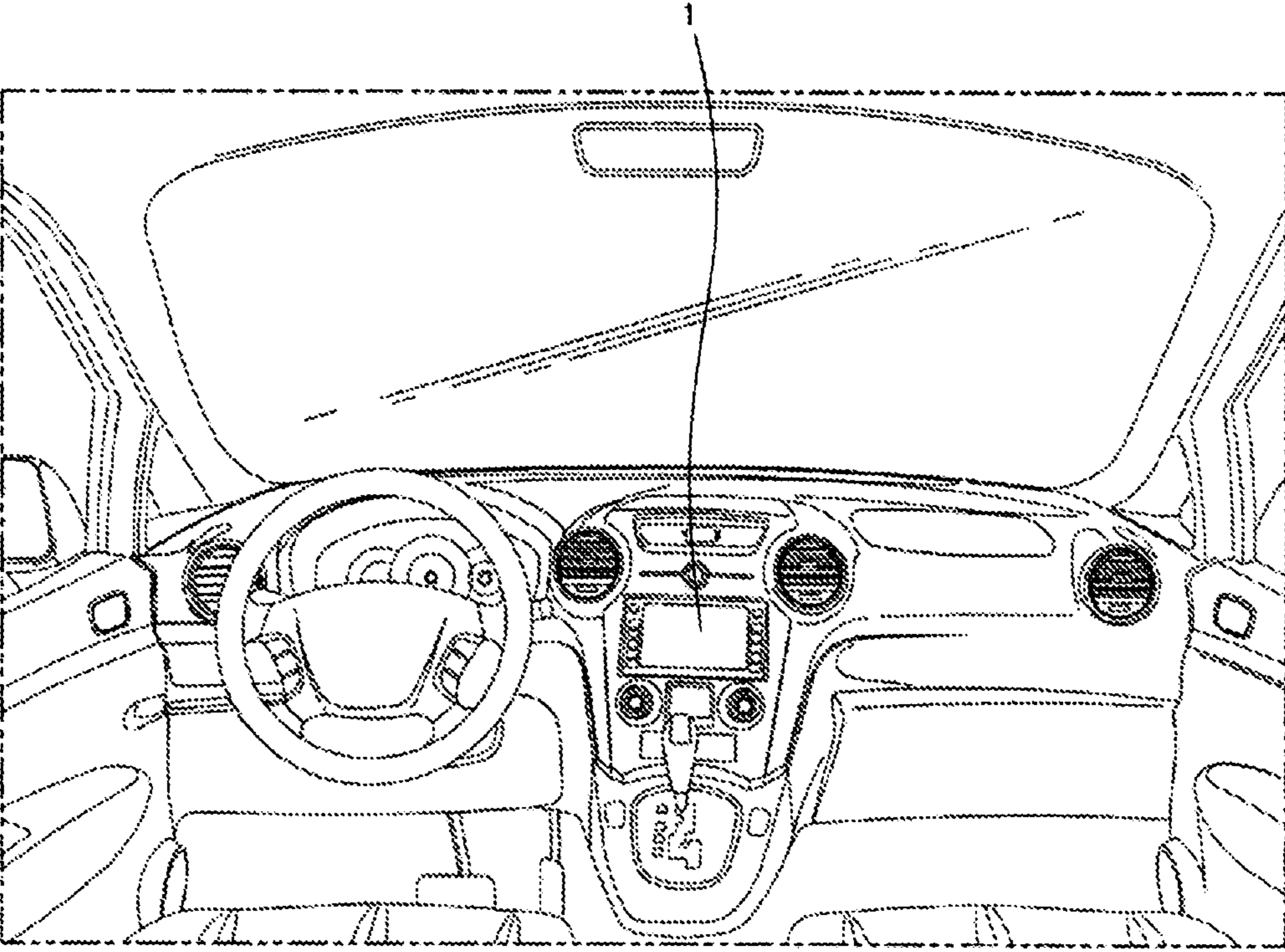


FIG. 11



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DISPLAY DEVICE INCLUDING A LIGHT GUIDE PLATE WITH PROTRUSIONS

CROSS REFERENCE TO RELATED APPLICATION

The present application is a continuation of U.S. patent application Ser. No. 17/556,239 filed on Dec. 20, 2021, which claims priority to Republic of Korea Patent Application No. 10-2021-0128552, filed Sep. 29, 2021, each of which is hereby incorporated by reference in its entirety.

BACKGROUND

Field of Technology

The present disclosure relates to a display device, and more particularly, to a display device having a limited viewing angle.

Description of the Related Art

As the information society progresses, various types of display devices are being developed. Recently, various display devices such as a liquid crystal display (LCD), a plasma display panel (PDP), and an organic light-emitting display (OLED) have been used.

A typical display device does not limit a viewing angle. However, the limitation of the viewing angle of the display device is recently required for the reasons of privacy and information protection. For example, in the case of a display device used as an information medium inside a vehicle, a high-definition image is provided to a passenger in a passenger seat, but a viewing angle needs to be limited to a driver for safety in driving.

SUMMARY

Embodiments provide a display device capable of effectively limiting a viewing angle.

The display device according to an embodiment may include a display panel configured to display an image; a first backlight unit disposed under the display panel, the first backlight unit configured to output first light and includes a first light guide plate, the first light guide plate comprising first patterns protruding or recessed from a rear surface of the first light guide plate; and a second backlight unit positioned between the display panel and the first backlight unit, the second backlight unit configured to output second light and includes a second light guide plate, the second light guide plate comprising second patterns protruding from a rear surface of the second light guide plate, the second patterns have an asymmetric pyramid shape.

In one embodiment, a display device that is provided in a vehicle comprises a display panel configured to display an image; a first backlight unit including a first light source package disposed under the display panel and a first light guide plate disposed on one side of the first light source package, the first backlight unit configured to generate first light and; and a second backlight unit including a second light source package positioned between the display panel and the first backlight unit and a second light guide plate disposed at one side of the second light source package, the second backlight unit configured to generate second light, wherein the second light guide plate includes second pat-

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terns protruding from a rear surface of the second light guide plate, the second patterns having an asymmetric pyramid shape.

In one embodiment, a display device comprises: a display panel configured to display an image; a first backlight unit under the display panel, the first backlight unit configured to output first light to the display panel; and a second backlight unit disposed between the display panel and the first backlight unit such that the display panel, the first backlight unit, and the second backlight unit overlap, wherein during a first mode of the display device the first backlight unit is enabled and the second backlight unit is disabled such that the image is displayed with a first side viewing angle, and wherein during a second mode of the display device the first backlight unit is enabled and the second backlight unit is enabled such that the image is displayed with a second side viewing angle that is greater than the first side viewing angle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a display device according to an embodiment.

FIG. 2 is a cross-sectional view schematically illustrating the structure of the first light guide plate shown in FIG. 1 according to an embodiment.

FIG. 3 is a view schematically illustrating a pattern formed on a lower surface of the first light guide plate according to an embodiment.

FIG. 4 is a cross-sectional view schematically illustrating the structure of the second light guide plate shown in FIG. 1 according to an embodiment.

FIGS. 5 and 6 are views schematically illustrating a pattern formed on a lower surface of the second light guide plate according to an embodiment.

FIG. 7 is a view schematically illustrating a path of light passing through a first light guide plate in a first mode of a display device according to an embodiment.

FIG. 8 is a view schematically illustrating a path of light passing through a second light guide plate in a second mode of a display device according to an embodiment.

FIG. 9 is a simulation result obtained by measuring luminance distribution in a first mode and a second mode of a display device according to an embodiment.

FIG. 10 is a graph showing luminance distribution in a first mode and a second mode of a display device according to an embodiment.

FIG. 11 is a view illustrating an example to which a display device according to an embodiment is applied.

DETAILED DESCRIPTION

Hereinafter, embodiments will be described with reference to the drawings. In this specification, when a component (or region, layer, portion, etc.) is referred to as “on,” “connected to,” or “coupled to,” another component, it means that the component can be directly connected/coupled to the other component or that a third component can be placed between them.

Like reference numerals refer to like elements. In addition, in the drawings, thicknesses, ratios, and dimensions of components are exaggerated for an effective description of technical content. In addition, “and/or” includes any combination of one or more that the associated configurations may define.

Terms such as first, second, etc. may be used to describe various elements, but the elements are not limited by the terms. The above terms are used only for the purpose of

distinguishing one component from another component. For example, without departing from the scope of the present embodiments, a first component may be referred to as a second component, and similarly, the second component may also be referred to as the first component. The singular expression includes the plural expression unless the context clearly dictates otherwise.

Terms such as “lower”, “below”, “above”, “upper” and the like are used to describe the relationship of the components shown in the drawings. The above terms are relative concepts, and are described with reference to directions indicated in the drawings.

The term such as “comprise” or “have” is intended to designate that there is a feature, number, step, operation, component, part, or a combination thereof described in the specification, but it should not be understood that it precludes the possibility of the existence or addition of one or more other features or number, step, operation, component, part or combinations thereof.

FIG. 1 is an exploded perspective view of a display device according to an embodiment. FIG. 2 is a cross-sectional view schematically illustrating the structure of the first light guide plate shown in FIG. 1 according to an embodiment, and FIG. 3 is a view schematically illustrating a pattern formed on a lower surface of the first light guide plate according to an embodiment. FIG. 4 is a cross-sectional view schematically illustrating the structure of the second light guide plate shown in FIG. 1 according to an embodiment, and FIGS. 5 and 6 are views schematically illustrating a pattern formed on a lower surface of the second light guide plate according to an embodiment.

Referring to FIG. 1, a display device 1 according to an embodiment may include a display panel 110 that displays an image including pixels, and first and second backlight units 120, 130 that are disposed on a rear surface of the display panel 110 to emit light toward the front of the display panel 110. As shown in FIG. 1, the display panel 110, the first backlight unit 120, and the second backlight unit 130 overlap each other. Although not shown, the display device 1 may further include a panel guide for receiving and fixing the display panel 110 and the first and second backlight units 120, 130, a top case, a bottom cover, and the like.

The display panel 110 is a liquid crystal panel, and may include a lower substrate and an upper substrate bonded to face each other, and a liquid crystal layer interposed between the substrates.

The lower substrate may include gate lines and data lines arranged to cross each other, and liquid crystal cells formed in an area where the gate lines and data lines cross each other. In an embodiment, the liquid crystal cells may be arranged in a matrix form on the lower substrate. The liquid crystal cells may include a thin film transistor disposed at an intersection region of the gate lines and the data lines, and a pixel electrode receiving a data voltage applied to the data lines through the thin film transistor when the thin film transistor is turned on.

Color filters for implementing a plurality of colors including red, green, and blue, and a black matrix for partitioning between the color filters and blocking the light passing through the liquid crystal layer and a common electrode for applying a voltage to the liquid crystal layer may be formed on the upper substrate.

The common electrode may be formed on the upper substrate in a vertical electric field driving type such as a twisted nematic (TN) mode and a vertical alignment (VA) mode, and may be formed on the lower substrate together

with the pixel electrode in a horizontal electric field driving type such as an in-plane switching (IPS) mode and a fringe field switching (FFS) mode.

The liquid crystal cells are driven according to an electric field generated by a potential difference between the data voltage supplied to the pixel electrode through the data lines and the common voltage supplied to the common electrode to adjust the amount of light transmitted from the display panel 110.

The first and second backlight units 120, 130 are disposed under the display panel 110 to provide light to the display panel 110. The first backlight unit 120 may be disposed under the display panel 110, and the second backlight unit 130 may be interposed between the first backlight unit 120 and the display panel 110.

The first backlight unit 120 may include a first light source package 121, a first light guide plate 122, a first diffusion sheet 123, a first prism sheet 124, and a first light control film 125.

The first light source package 121 may be driven by receiving power from outside and generating light. The first light source package 121 may generate light using various light sources such as a cold cathode fluorescent lamp (CCFL), an external electrode fluorescent lamp (EEFL), a hot cathode fluorescent lamp (HCFL), or a light-emitting diode (LED). The first light source package 121 is disposed to face at least one side of the first light guide plate 122. Accordingly, the light emitted from the first light source package 121 may be incident on the side of the first light guide plate 122.

The first light guide plate 122 is disposed to face one side of the first light source package 121 and guides the light incident from the first light source package 121 to emit it to an upper surface. In an embodiment, the first light guide plate 122 is a light-transmitting material, and may be made of, for example, a plastic material such as polymethyl methacrylate (PMMA) or a material selected from polycarbonate (PC) type materials. However, the material of the first light guide plate 122 is not limited to the above, and the first light guide plate 122 may be made of other materials.

Referring to FIGS. 2 and 3, first patterns 122a, each being polygonal and protruding, may be formed on a rear surface of the first light guide plate 122. The first patterns 122a may be embossed on the rear surface of the first light guide plate 122 through injection or printing. In another embodiment, the first patterns 122a may be formed in an intaglio shape recessed in the rear surface of the first light guide plate 122. The first patterns 122a may be disposed by regularly or irregularly spaced apart from each other.

In an embodiment, the first patterns 122a may have a pyramid shape. In this case, the first patterns 122a may have a symmetrical shape in which inclinations of the four sides forming the pyramid are the same or substantially similar. In an embodiment, the length (L1) of one side of the symmetric pyramid may be about 10 μm to 50 μm , for example, about 30 μm . Also, in an embodiment, the angle (a) between the rear surface of the first light guide plate 122 and one side of the symmetric pyramid is about 20° to 60°, for example, about 40°. The vertex angle (b) of the symmetric pyramid may be about 100°. The height (h1) of the symmetric pyramid may be determined according to the size and inclination of the four sides, and may be, for example, 5 μm to 30 μm . However, the present embodiment is not limited thereto.

In another embodiment, the first patterns 122a may have a dot shape. In one embodiment, the diameter of the dot may

be about 40 μm to 100 μm , and the depth of the dot may be about 2 μm to 30 μm . However, the present embodiment is not limited thereto.

An emission angle of the light incident from the first light source package **121** to the first light guide plate **122** may be controlled by the first patterns **122a** formed on the rear surface. Since the first patterns **122a** have a symmetric pyramid shape or a dot shape, the light refracted on four sides or curved surfaces of the first pattern **122a** may be partially emitted in the lateral direction as well as the upper surface of the first light guide plate **122**.

The first diffusion sheet **123** and the first prism sheet **124** are disposed on the first light guide plate **122**. The first diffusion sheet **123** diffuses the light emitted from the first light guide plate **122** to improve luminance uniformity according to the viewing angle. The first diffusion sheet **123** may be formed of PET or polycarbonate (PC) resin, and may include a particle coating layer serving as diffusion. The first prism sheet **124** condenses the light so that the traveling direction of the light emitted from the first light guide plate **122** or the first diffusion sheet **123** approaches the normal direction of the display panel **110**, and thus the front luminance of the display panel **110** is improved. In one embodiment, the first prism sheet **124** may include a first upper prism sheet **124a** and a first lower prism sheet **124b** in which a prism pattern is formed and axes of the prism pattern are arranged orthogonally to each other.

The first light control film (LCF) **125** is disposed on the first prism sheet **124**. The first light control film **125** may control the profile of the emitting light of the first backlight unit **120** together with the first patterns **122a**. For example, the first light control film **125** may adjust the left and right and/or vertical viewing angles of the light emitted from the first backlight unit **120** to be narrow.

The second backlight unit **130** is disposed on the first backlight unit **120**. The second backlight unit **130** may include a second light source package **131**, a second light guide plate **132**, and a second light control film **133**.

The second light source package **131** may be driven by receiving power from outside and generating light. The second light source package **131** generates light using various light sources such as a cold cathode fluorescent lamp (CCFL), an external electrode fluorescent lamp (EEFL), a hot cathode fluorescent lamp (HCFL) or a light-emitting diode (LED). The second light source package **131** is disposed to face at least one side of the second light guide plate **132**. Accordingly, the light emitted from the second light source package **131** may be incident on the side of the second light guide plate **132**.

In an embodiment, the second light source package **131** may be disposed on a different side from the first light source package **121**. For example, when the first light source package **121** is disposed on the first side of the display device **1**, the second light source package **131** may be disposed on at least one of the second to fourth sides of the display device **1**. For example, the second light source package **131** may be disposed on the left/right side, only on the left side, or only on the right side of the display device **1**. In addition, the number of the second light source packages **131** may be the same as or different from the number of the first light source packages **121**. For example, when one first light source package **121** is provided as illustrated, two or more second light source packages **131** may be provided. In this embodiment, two or more second light source packages **131** may be disposed to face each

other with the second light guide plate **132** interposed therebetween, but the present embodiment is not limited thereto.

The second light guide plate **132** is disposed to face the second light source package **131**, and guides the light incident from the second light source package **131** to emit the light to the upper surface. In an embodiment, the second light guide plate **132** is a light-transmitting material and may be made of, for example, a plastic material such as polymethyl methacrylate (PMMA) or a material selected from polycarbonate (PC) type materials.

Referring to FIGS. **4** and **5**, second patterns **132a**, each being polygonal and protruding, may be formed on the rear surface of the second light guide plate **132**. The second patterns **132a** may be embossed on the rear surface of the second light guide plate **132** through injection or printing. The second patterns **132a** may be disposed of by regularly or irregularly spaced apart from each other.

In an embodiment, the second patterns **132a** may have a pyramid shape. In this case, the second patterns **132a** may have an asymmetric shape in which at least some of the inclinations of the four sides forming the pyramid have different angles. In this embodiment, in the second patterns **132a**, the inclination of the first side **S1** distant from the second light source package **131** may be steeper than the inclination of the second side **S2** close to the second light source package **131**.

That is, the angle (d) between the first side **S1** distant from the second light source package **131** of the second patterns **132a** and the rear surface of the second light guide plate **132** is greater than the angle (c) between the second side **S2** close to the light source package **131** of the second patterns **132a** and the rear surface of the second light guide plate **132**. In this case, if the inclination is steep, the acute angle between the normal of the corresponding side (here, the first side **S1**) and the rear surface of the second light source package **131** may be less than 45 degrees (generally horizontal). Conversely, if the inclination is gentle, the acute angle between the normal of the corresponding side (here, the second side **S2**) and the rear surface of the second light source package **131** may be greater than 45 degrees (generally vertical).

In one embodiment, the length of one side of the asymmetric pyramid may be about 20 μm to 100 μm , for example, a long side length (**L2**) may be about 50 μm , and a short side length (**L3**) may be about 30 μm . Also, in an embodiment, the angles (c, d) between the rear surface of the second light guide plate **132** and the four sides of the asymmetric pyramid are about 20° to 60°, for example, about 50° to 60°. The apex angle (e) of the asymmetric pyramid may be about 60° to 80°. The height (**h2**) of the asymmetric pyramid may be determined according to the size and inclinations of the four sides, and may be, for example, 5 μm to 30 μm . However, the present embodiment is not limited thereto.

Referring to FIG. **6**, the ratio of the length (**L2**) of the long side to the height (**h2**) of the second patterns **132a** may be set in a range of about 0.5 to 20. For example, the ratio of the length (**L2**) to height (**h2**) of the long side of the second patterns **132a** may be set to 100:14.2. In addition, the ratio of the distance (**L4**) to one short side and the distance (**L5**) to the other short side, from perpendicular foot down from the vertex to bottom of the second patterns **132a**, may be set to about 0.4. As an example, the ratio of the distance (**L4**) to one short side and the distance (**L5**) to the other short side, from the perpendicular foot down from the vertex to bottom of the second patterns **132a** may be about 1:9 to 5:5, preferably 3:7. However, the present embodiment is not limited thereto.

The second light control film **133** is disposed on the second light guide plate **132**. The second light control film **133** may control the profile of emitted light of the second backlight unit **130** together with the second patterns **132a**. For example, the second light control film **133** may adjust the left and right and/or vertical viewing angles of the light emitted from the second backlight unit **130** to be narrow angles. In various embodiments, an optical film such as a UV blocking film (LAF) may be further provided or may be omitted.

Hereinafter, a specific embodiment in which the side viewing angle of the display device **1** is controlled through the backlight units **120**, **130** having the above structure will be described.

FIG. **7** is a view schematically illustrating a path of light passing through a first light guide plate **122** in a first mode of the display device **1** according to an embodiment, and FIG. **8** is a view schematically illustrating a path of light passing through a second light guide plate **132** in a second mode of the display device **1** according to an embodiment. FIG. **9** is a simulation result obtained by measuring luminance distribution in a first mode and a second mode of a display device according to an embodiment, and FIG. **10** is a graph showing luminance distribution in a first mode and a second mode of a display device according to an embodiment.

The display device **1** according to an embodiment may operate in any one of a first mode and a second mode. For example, the first mode is a private mode, and may be a mode for limiting a side viewing angle of the display device **1**. Also, the second mode is a sharing mode and may be a mode that does not limit the side viewing angle of the display device **1**. Thus, the sharing mode has a larger viewing angle than the private mode.

Referring to FIG. **1** together, in the private mode, the first light source package **121** of the first backlight unit **120** is turned on, and the second light source package **131** of the second backlight unit **130** is turned off. Thus, in the private mode the first backlight unit **120** is enabled and the second backlight unit **130** is disabled.

Referring to FIG. **7**, the emission angle of the light emitted from the first light source package **121** is controlled by the first patterns **122a** formed on the rear surface of the first light guide plate **122**, and the light is emitted to the upper surface of the first light guide plate **122**. The light emitted to the upper surface of the first light guide plate **122** passes through the first diffusion sheet **123**, the first prism sheet **124**, and the first light control film **125** and is incident on the rear surface of the second backlight unit **130**.

The emission angle of the light incident on the rear surface of the second backlight unit **130** is controlled by the second patterns **132a** formed on the rear surface of the second light guide plate **132**. Since the second patterns **132a** have an asymmetric pyramid shape, the light incident on the second light guide plate **132** may be controlled to be emitted to the upper surface of the second light guide plate **132** at a narrow angle or may be controlled to be emitted in the lateral direction.

For example, when the second light source package **131** is turned off, the light emitted from the first backlight unit **120** may be incident on the second light guide plate **132**. The light incident on the rear surface of the second light guide plate **132** may be refracted on the inclined surfaces of the second patterns **132a** and then emitted upward. In particular, the light incident on the rear surface of the second light

guide plate **132** has an emission angle further limited to a narrow angle by the gently inclined surfaces of the second patterns **132a**.

More specifically, the light incident on the rear surface of the second light guide plate **132** reaches more than the second side **S2** thereof, which is a relatively large area in the second patterns **132a**. Since the normal of the second side **S2** has an angle greater than 45 degrees (generally perpendicular) with respect to the rear surface of the second light guide plate **132**, the light incident on the rear surface proceeds generally vertically with respect to the rear surface according to the normal direction of the second side **S2**. That is, the light incident on the rear surface is emitted substantially perpendicular to the rear surface (or upper surface) of the second light guide plate **132**. As a result, for the light incident on the rear surface, the emission in the lateral direction is limited, and the emission angle is limited only in a direction substantially perpendicular to the upper surface of the second light guide plate **132**, so that the emission angle is limited to a narrow angle.

As such, when the emission angle is controlled to be narrow by the second patterns **132a**, the viewing angle from the side of the display device **1** is limited, and the display device **1** may operate in the first mode, that is, in the private mode.

The light emitted from the second backlight unit **130** is applied to the display panel **110**, and an image is an output in an upper direction of the display device **1** through the pixels disposed on the display panel **110**. Since the emission angle of the light emitted from the second backlight unit **130** is limited in the upper direction, the image output through the display panel **110** has high luminance in the front direction as shown in FIGS. **9** and **10**, and the image display is limited in the lateral direction. As such, since the side viewing angle of the display panel **110** is controlled in the private mode, an image may not be viewed by a user who looks at the display panel **110** from the side of the display panel **110**.

In the sharing mode, the first light source package **121** of the first backlight unit **120** is turned on, and the second light source package **131** of the second backlight unit **130** is also turned on. Thus, in the sharing mode the first backlight unit **120** is enabled and the second backlight unit **130** is also enabled.

Referring to FIG. **8**, the light emitted from the first light source package **121** has an emission angle controlled by the first patterns **122a** formed on the rear surface of the first light guide plate **122**, and the light is emitted to the upper surface of the first light guide plate **122**. The light emitted to the upper surface of the first light guide plate **122** passes through the first diffusion sheet **123**, the first prism sheet **124**, and the first light control film **125**, and then is incident on the rear surface of the second backlight unit **130**.

As described with reference to FIG. **7**, an emission angle of the light incident on the rear surface of the second backlight unit **130** is controlled by the second patterns **132a** formed on the rear surface of the second light guide plate **132**. The light incident on the rear surface of the second backlight unit **130** may be restricted from being emitted in the lateral direction by the gently inclined surface of the second patterns **132a**, and may be emitted only in the upper direction of the narrow angle.

In the share mode, since the second light source package **131** is turned on, the light emitted from the second light source package **131** is further incident on the side surface of the second light guide plate **132**. This light incident in the lateral direction of the second light guide plate **132** is

refracted at the first side S1 of the second patterns 132a, and at least a portion of the light is emitted laterally, and the viewing angle at the side surface of the display device 1 may be increased.

More specifically, the light incident in the lateral direction of the second light guide plate 132 reaches the first side S1 of the second patterns 132a disposed opposite to each other. Since the normal of the first side S1 has an angle (generally horizontal) less than 45° with respect to the rear surface of the second light guide plate 132, the sidelight incident adjacent to the normal of the first side S1 is emitted adjacent to the normal of the first side S1 again.

Since the normal of the first side S1 has an angle less than 45 degrees (generally horizontal) with respect to the rear surface of the second light guide plate 132, the light incident on the side surface proceeds generally horizontally with respect to the rear surface according to the normal direction of the first side S1. That is, the light incident on the side surface is emitted in the lateral direction with respect to the rear surface (or the upper surface) of the second light guide plate 132. As a result, the light incident on the side surface is allowed to be emitted in the lateral direction, and the emission angle is increased to a wide angle.

As described above, when the emission angle is controlled to be wide by the second patterns 132a, the display device 1 may operate in the second mode, that is, the share mode. In the share mode, the range of the emission angle may be 0 to 88°, but is not limited thereto.

The light emitted from the second backlight unit 130 is applied to the display panel 110, and an image is an output in the upper direction of the display device 1 through the pixels disposed on the display panel 110. Since the light emitted from the second backlight unit 130 is transmitted in the upper direction and the lateral direction, an image output through the display panel 110 has high illuminance not only in the front direction but also in the lateral direction as shown in FIGS. 9 and 10. As described above, since the side viewing angle of the display panel 110 is opened in the share mode, an image may be viewed by a user who looks at the display panel 110 from the side of the display panel 110.

In the above, an embodiment in which the first backlight unit 120 is turned on in the first mode and the second mode and the second backlight unit 130 is turned on in the second mode has been described. However, the present invention is not limited thereto. For example, in other embodiments, the first backlight unit 120 may be turned off in at least one of the first modes and the second mode, and the second backlight unit 130 may be turned on in the first mode and turned off in the second mode. In various embodiments, the first backlight unit 120 and the second backlight unit 130 may be controlled in various ways.

FIG. 11 is a view illustrating an example to which a display device according to an embodiment is applied.

Referring to FIG. 11, the display device 1 according to an embodiment may be provided inside a vehicle. The display device 1 may be provided integrally or detachably on the dashboard of the vehicle.

The display device 1 may display graphical user interfaces (GUIs) corresponding to navigation, video contents, and sound contents according to a driving state and/or a user's request.

In an embodiment, the display device 1 may operate in the private mode while the vehicle is being driven. For example, the display device 1 may operate in the private mode when displaying an image determined to interfere with a user's driving, such as moving image content. In this embodiment,

the display device 1 may control the second light source package 131 to be turned off to limit a side viewing angle of the driver seat.

In an embodiment, the display device 1 may operate in the sharing mode while the vehicle is not driving. Alternatively, the display device 1 may operate in the sharing mode even while the vehicle is being driven. For example, the display device 1 may operate in the sharing mode when displaying an image determined to assist the user in driving, such as navigation. In this embodiment, the display device 1 may control the second light source package 131 to be turned on to open a side viewing angle for the driver seat.

The display device according to embodiments may efficiently control a viewing angle by forming an asymmetric pyramidal pattern on a lower surface of a light guide plate of an upper backlight unit in the backlight in which a multi-layer light guide plate is stacked.

The display device according to embodiments may improve cut-off efficiency for limiting a view from a driver seat, and provide a driver seat with a viewing of an image with improved luminance if necessary.

The display device according to embodiments may control the range of a viewing angle and cut-off efficiency by adjusting the size, height, and side angle of a pattern having an asymmetric pyramid shape.

Those of ordinary skill in the art to which the present invention pertains will understand that the present invention may be implemented in other specific forms without changing the technical spirit or essential features thereof. Therefore, it should be understood that the embodiments described above are illustrative in all respects and not restrictive. The scope of the present invention is referred by the claims to be described later rather than the above-detailed description, and it should be interpreted that all changes or modifications derived from the meaning and scope of the claims and their equivalent concepts are included in the scope of the present invention.

What is claimed is:

1. A display device comprising:

- a first backlight unit configured to output first light, the first backlight unit including a first light source package configured to generate the first light and a first light guide plate;
- a first light control film on the first backlight unit, the first light control film configured to adjust a first direction of a viewing angle of the display device;
- a second backlight unit on the first light control film and configured to output second light, the second backlight unit including a second light source package configured to generate the second light and a second light guide plate;
- a display panel on the second backlight unit such that the second backlight unit is between the display panel and the first backlight unit, the display panel configured to display an image;
- wherein the second light guide plate comprises a plurality of second patterns protruding from a rearmost surface of the second light guide plate in a direction toward an upper surface of the first light guide plate,
- wherein the plurality of second patterns have an asymmetric pyramid shape, with a first inclined surface and a second inclined surface that is steeper than the first inclined surface, and
- wherein the second light source package is adjacent to the first inclined surface of the plurality of second patterns.

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2. The display device according to claim 1, wherein the first light is output from a rear side of the first light guide plate to a front side of the first light guide plate.

3. The display device according to claim 1, wherein the first light source package and the second light source package are non-overlapping in a cross-section view of the display device.

4. The display device according to claim 1, wherein the display device further comprises:

a second light control film on the second light guide plate, the second light control film configured to adjust a second direction of the viewing angle of the display device.

5. The display device according to claim 4, wherein the first direction and the second direction are perpendicular.

6. The display device according to claim 4, wherein viewing angles of the first light and the second light from the display panel are a same in the second direction.

7. The display device according to claim 4, wherein viewing angles of the first light from the display panel are narrower than viewing angles of the second light in the first direction.

8. The display device according to claim 1, wherein during a first mode of the display device the first light source package is turned on to enable the first backlight unit and the second light source package is turned off to disable the second backlight unit such that the first light is emitted at a narrow angle in a front direction of the display panel by a first pattern of protrusions on a rear surface of the first light guide plate and the first inclined surface of the second pattern, and

wherein during a second mode of the display device the first light source package is turned on to enable the first backlight unit and the second light source package is turned on to enable the second backlight unit such that the second light is further emitted to a side by the second inclined surface of the second pattern.

9. The display device according to claim 8, wherein the first mode is a private mode and the second mode is a share mode.

10. The display device according to claim 1, wherein the second light guide plate is on at least one side of the second

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light source package, the second light guide plate configured to guide the second light incident from the second light source package to the display panel,

wherein among four sides of the asymmetric pyramid shape of each of the plurality of second patterns comprises an angle between a first side distant from the second light source package and the rearmost surface of the second light guide plate that is greater than an angle between a second side closer to the second light source package and the rearmost surface of the second light guide plate.

11. The display device according to claim 1, wherein the first light guide plate is configured to guide the first light emitted from the first light source package to the rearmost surface of the second light guide plate, and

the first light incident on a lower surface of the second light guide plate is refracted at a second side of the plurality of second patterns and is emitted in an upper direction substantially perpendicular to an upper surface of the second light guide plate.

12. The display device according to claim 1, wherein the second light emitted from the second light source package is refracted at a first side of the plurality of second patterns, the refracted second light having at least a portion that is laterally emitted with respect to an upper surface of the second light guide plate.

13. The display device according to claim 1, wherein an inclination of four inclined surfaces of each of the plurality of second patterns is in a range of angles between 5° to 60°.

14. The display device according to claim 1, wherein a length of a long side of each of the plurality of second patterns is in a range between 1 μm to 100 μm and a height of the long side of each of the plurality of second patterns is in a range between 1 μm to 50 μm.

15. The display device according to claim 1, wherein a ratio of a distance to one short side and a distance to another short side measured from a point that is perpendicular from a vertex to a bottom of each of the plurality of second patterns is in a ratio range of 1:9 to 5:5.

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